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AIR FORCE OFFICER QUALIFYING TEST (AFOQT) AND ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB): ANALYSIS OF COMMON MEASUREMENT ATTRIBUTES

Todd C. Sperl
Malcolm James Ree
Kurt W. Steuck

MANPOWER AND PERSONNEL DIVISION
Brooks Air Force Base, Texas 78235-5601

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WILLIAM E. ALLEY, Technical Director
Manpower and Personnel Division

HAROLD G. JENSEN, Colonel, USAF
Commander

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Todd C. Sperl
Malcolm James Ree
Kurt W. Steuck

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13. ABSTRACT (Maximum 200 words)
This investigation explores the relationship of the verbal and quantitative components of the Air Force Officer Qualifying Test (AFOQT) and the Armed Services Vocational Aptitude Battery (ASVAB). Subjects were 516 airmen in Basic Military Training (BMT) who took the ASVAB prior to enlistment. They were administered the verbal and quantitative components of the AFOQT. A matrix of ASVAB subtests and AFOQT verbal and quantitative subtest correlations was computed. After correction for restriction in range, high correlations were found between AFOQT and ASVAB subtests of the same attributes. Using the corrected matrix, the following analyses were performed. Regressions were conducted to predict AFOQT success using ASVAB subtests. All ASVAB subtests but Word Knowledge were significant ($p < .01$) in the prediction equation. Principal components factor analyses were conducted to find the structure of the tests. Five factors best represented the data. Finally, canonical correlation results indicated three statistically significant ($p < .01$) variates. Several conclusions may be drawn. The intercorrelations and factor analysis indicated that both tests measure similar attributes. The regression analyses showed that the ASVAB could be used to predict the AFOQT. Finally, canonical correlation results indicated strong convergent validity of the AFOQT and ASVAB. Keywords: correlation techniques, factor analysis, prediction, aptitude tests, intelligence tests (EHK)

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SUMMARY

The United States Air Force has two separate personnel selection and classification systems: one for officers and one for enlisted personnel. The Armed Services Vocational Aptitude Battery (ASVAB) is used for selecting enlisted personnel to occupational specialties, and the Air Force Officer Qualifying Test (AFOQT) is used in the selection and classification of officer candidates. Despite the similar uses of the tests, no study has been conducted to explore the relationship between the AFOQT and ASVAB. The present investigation evaluated the verbal and quantitative components of these two instruments for common measurement properties.

A sample of 516 airmen in Basic Military Training (BMT) was administered the Verbal, Quantitative, and Academic Aptitude composites of the AFOQT Form O. These airmen had taken the ASVAB prior to enlistment.

Analyses were conducted to describe and evaluate the relationship between the two tests. An intercorrelation matrix containing ASVAB subtests and AFOQT verbal and quantitative subtests was computed. Correlations were corrected for restriction in range. Using the corrected correlation matrix, stepwise regressions were conducted. Principal components factor analyses were conducted to find the common structure of the tests. Finally, a canonical correlation was performed to relate the sets of subtests.

Results of the intercorrelations and factor analysis indicated that both tests measure similar attributes. The regression analyses showed that specific parts of the ASVAB could be used to predict verbal and quantitative scores on the AFOQT. Finally, canonical correlation results indicated strong convergent validity of the AFOQT and ASVAB. The major conclusion drawn was that the AFOQT and ASVAB measure similar aptitudes and abilities. Several other conclusions may be drawn regarding the common elements of the AFOQT and ASVAB. These findings have implications for future test form item development and tryout, and for how the two tests are used operationally.

PREFACE

The Air Force Human Resources Laboratory (AFHRL) is tasked as the test development agency for the Air Force Officer Qualifying Test (AFOQT) by Air Force Regulation 35-8, Air Force Military Personnel Testing System. The current research and development (R&D) effort was undertaken as part of AFHRL's responsibility to develop, revise, and conduct research in support of the AFOQT. This research was completed under 771918, Selection and Classification Technologies, which is part of a larger effort in the Force Acquisition and Distribution Systems. It was subsumed under work unit number 77191847, Development and Validation of Civilian and Nonrated Officer Selection Methodologies.

Special appreciation is extended to Mr. Roy Chollman and other test examiners at the Air Force Human Resources Laboratory (AFHRL) test facility at Lackland AFB, Texas, and Mr. William Glasscock of the AFHRL Information Sciences Division. Their efforts were instrumental to the successful accomplishment of the data collection and data analysis phases of this effort.

TABLE OF CONTENTS

LIST OF TABLES

AIR FORCE OFFICER QUALIFYING TEXT (AFOQT) AND
ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB):
ANALYSIS OF COMMON MEASUREMENT ATTRIBUTES

I. INTRODUCTION

The United States Air Force has two separate systems for personnel selection and classification. The Armed Services Vocational Aptitude Battery (ASVAB) is the test used for selection and classification of enlisted personnel to occupational specialties, and the Air Force Officer Qualifying Test (AFOQT) is used in the selection and classification of officer candidates. The enlisted selection system is concerned with obtaining high school graduates and selected non-graduates for technical training and subsequent assignment in occupational areas such as administration, mechanics, electronics or aircraft maintenance. The officer selection and classification system is concerned with two commissioning programs: Officer Training School (OTS) and Air Force Reserve Officer Training Corps (AFROTC). This includes commissioning college graduates for managerial, professional, and specialized (e.g., pilot and navigator) careers (Rogers, Roach, & Short, 1986). The United States Air Force Academy is a third source of commissioning; however, the AFOQT is not used for that program.

The ASVAB has been the enlisted military personnel selection and classification test since 1976, and has been used in high schools for career counseling since 1968. The content of the ASVAB reflects those subject areas which have shown validity for prediction of training criteria in each of the Services (Bayroff & Fuchs, 1970). The ASVAB consists of 10 subtests that measure the different types of skills and knowledge areas found necessary in military jobs by occupational analysts (U.S. Department of Defense, 1984): General Science (GS), Arithmetic Reasoning (AR), Word Knowledge (WK), Paragraph Comprehension (PC), Numerical Operations (NO), Coding Speed (CS), Auto and Shop Information (AS), Mathematical Knowledge (MK), Mechanical Comprehension (MC), and Electronics Information (EI). NO and CS are speeded subtests and the others are power subtests.

Table 1 provides brief definitions of the 10 ASVAB subtests. Four subtests--Word Knowledge, Paragraph Comprehension, Arithmetic Reasoning, and Mathematical Knowledge--are weighted and combined to form the Armed Forces Qualification Test (AFQT) composite. The AFQT score is used by all the Services as an indicator of general trainability and is one measure of the quality of the enlisted force often included in reports to Congress.

The AFOQT is one of several selection criteria used for the OTS and AFROTC commissioning programs (Cowan, Barrett, & Wegner, 1989, 1990). The AFOQT measures general intellectual ability, as well as aptitudes requisite to success as a pilot or navigator. It is composed of 16 subtests aggregated into five composites: Verbal, Quantitative, Academic Aptitude (a combination of Verbal and Quantitative), Pilot, and Navigator-Technical. The first three composites are used for selection purposes; the latter two, for classification into flying specialties (Rogers, Roach, & Short, 1986). Table 2 briefly defines the 16 AFOQT subtests. The first 6 subtests comprise the Verbal and Quantitative composites, which combined form the Academic Aptitude composite. The remaining 10 subtests are used in the classification of rated officers (pilots and navigators).

Despite the similar uses of the tests for military personnel selection and classification, no studies have been conducted to explore the relationship between the AFOQT and ASVAB. The present investigation evaluates the verbal and quantitative components of these two aptitude tests in terms of the commonality of their measured attributes. The benefits of this research go beyond scientific curiosity. Findings have implications for mobilization, item pool development, possible "g" factors, convergent validity, and the Airmen Education and Commissioning Program (AECP).

Table 1. **Description of Items in ASVAB Subtests**

ASVAB subtests	No. of items	Definition
General Science (GS)	25	Knowledge of or about physical, chemical, and life properties.
Arithmetic Reasoning (AR)	30	Reasoning required to perform arithmetic processes.
Word Knowledge (WK)	35	Knowledge of the meaning of selected words.
Paragraph Comprehension (PC)	15	Understanding of written material from brief paragraphs.
Numerical Operations (NO)	50	Knowledge of simple addition, subtraction, multiplication, and division.
Coding Speed (CS)	84	Ability to identify and match sets of numbers with words.
Auto and Shop Information (AS)	25	Knowledge of and familiarity with tools and shop practices, maintenance, structure, and repair of automobiles.
Mathematical Knowledge (MK)	25	Application of learned mathematics principles.
Mechanical Comprehension (MC)	25	Understanding and application of various mechanical principles.
Electronics Information (EI)	20	Identification or application of simple electric or electronics knowledge.

Note. NO and CS are speeded subtests.

Could ASVAB subtests be used to predict performance on the AFOQT if the need for officers increased rapidly? This would allow the Air Force to administer the AFOQT more efficiently to potential officer candidates. Many high school students are administered the ASVAB. Of those tested, some enlist, some go to college, and some join the civilian workforce. Those enlisted personnel or civilians who receive a college degree are potential officer candidates. If the ASVAB were found to predict performance on the AFOQT, the enlisted test could be used as a pre-selection tool for deciding who to test first in the event of wartime mobilization requiring a buildup of the officer force.

During test construction of the AFOQT and ASVAB, about three times the number of items used in the operational form are developed and tested. This procedure results in large pools of items for both tests and ensures some latitude in identifying statistically acceptable items that most closely match the characteristics needed. If subtests from the AFOQT and ASVAB were found to measure the same attributes, the item pools could be combined and used more efficiently in test construction.

Table 2. **Description of AFOQT Subtests**

AFOQT Subtests	No. of items	Definition
Verbal Analogies (VA)	25	Measures ability to reason and recognize relationships between words.
Arithmetic Reasoning (AR)	25	Measures ability to understand and reason with arithmetic relationships through word problems.
Reading Comprehension (RC)	25	Measures ability to read and understand paragraphs.
Data Interpretation (DI)	25	Measures ability to interpret data from graphs and charts.
Word Knowledge (WK)	25	Measures ability to understand written language through use of synonyms.
Math Knowledge (MK)	25	Measures ability to use learned math knowledge, terms, formulas, and relationships.
Mechanical Comprehension (MC)	20	Measures mechanical knowledge and understanding of mechanical functions.
Electrical Maze (EM)	20	Measures spatial ability to choose a correct path through a maze.
Scale Reading (SR)	40	Measures ability to read scales and dials.
Instrument Comprehension (IC)	20	Measures ability to determine aircraft attitude from flight instruments.
Block Counting (BC)	20	Measures spatial ability to "see into" a three-dimensional pile of blocks.
Table Reading (TR)	40	Measures ability to read tables quickly and accurately.
Aviation Information (AI)	20	Measures knowledge of general aeronautical concepts and terminology.
Rotated Blocks (RB)	15	Measures spatial aptitude by visualizing and manipulating objects in space.
General Science (GS)	20	Measures knowledge and understanding of scientific terms, concepts, principles, and instruments.
Hidden Figures (HF)	15	Measures perceptual and visual imagery ability using simple figures embedded in complex drawings.

Spearman (1904, 1927) hypothesized that the positive correlation among all cognitive tests is due to "g," a general ability factor that is measured by every test. Subtest content indicates that the verbal and quantitative tests on the AFOQT and ASVAB should measure the same attributes but on a different scale. Does the "g" factor found by Spearman (1904,1927) exist in the AFOQT and ASVAB? If both AFOQT and ASVAB are heavily saturated with "g," then the tests may be assumed to measure the same attribute and the ASVAB could be used to predict AFOQT.

Convergent validity is demonstrated by high correlations between scores on tests measuring the same trait (Allen & Yen, 1979). If high correlations were found between the AFOQT and ASVAB on similar subtests, convergent validity could be confirmed.

The Airman Education and Commissioning Program (AECP) allows airmen on active duty to earn baccalaureate degrees in needed academic fields. Graduates then complete requirements for a commission by attending Officer Training School (OTS). Studies have shown the AFOQT (one of the eligibility requirements for the AECP) to be a valid predictor of success in OTS (Cowan et al., 1990). If specific subtests of the ASVAB predict success on the AFOQT, the AECP could use an applicant's ASVAB score as a pre-screening device.

II. METHOD

Subjects

Subjects were 516 airmen in Basic Military Training (BMT) at Lackland AFB, Texas, who were administered the AFOQT and ASVAB. Table 3 provides the demographics of the sample. As shown, a majority of the examinees were white (84%) and had a high school diploma or better (99%) at the time of ASVAB testing. Approximately three-quarters of the subjects were male (76%), with the average age at time of ASVAB testing just over 18 1/2 years and the average age at AFOQT administration about 19 1/2 years.

Table 3. **Sample Demographic and Background Information**

		Age in years at time of testing		
Ethnicity	**Percentage**		**Mean**	**SD**
Black	10.47			
White	83.95			
Hispanic	4.26	ASVAB	18.69	2.18
Other	2.33	AFOQT	19.58	1.93

Gender	**Percentage**	**Academic education level**	**Percentage**
Male	75.78	3-4 Years High School	.78
Female	24.22	High School Diploma	88.76
		1 Year College	5.04
		2 Years College	2.71
		3-4 Years College	1.16
		College Graduate	1.55

Procedure

Subjects were administered Form O of the AFOQT between August 1987 and November 1987, concurrent with their attendance at BMT. Testing was conducted on the six AFOQT subtests

(VA, AR, RC, DI, WK, MK) which comprise the Verbal, Quantitative, and Academic Aptitude composites. Examinees' responses were collected on the General Answer Sheet Type C.

Answer sheets were optically scanned and an AFOQT record created for each examinee. AFOQT records were then matched using examinees' social security account numbers (SSANs) to a file provided by the Military Entrance Processing Command (MEPCOM) which contained ASVAB records for Air Force applicants. A 100% SSAN match was obtained; none of the 516 subjects was lost from the sample for failure to identify their ASVAB records. The MEPCOM file indicated that examinees had tested on ASVAB Forms 11, 12, 13, and 14.

Variables

The variables used in the analyses were: (a) AFOQT Form O raw scores on the VA, AR, RC, DI, WK, and MK subtests and percentile scores on the Verbal, Quantitative, and Academic Aptitude composites; (b) ASVAB Forms 11, 12, 13, and 14 raw scores on all 10 subtests and the Armed Forces Qualification Test (AFQT) score computed as a weighted sum of subtest standard scores as follows: 2(WK + PC) + AR + MK.

Of the 150 AFOQT items administered to the basic airmen, a total of 10 items had been previously deleted from scoring due to double keys, miskeys, or poor item performance (Rogers, Roach, & Wegner, 1986). By subtest, the omitted items were as follows: 3 in Verbal Analogies, 4 in Arithmetic Reasoning, 2 in Data Interpretation, and 1 in Word Knowledge. The Verbal composite was scored using the items from the Verbal Analogies, Reading Comprehension, and Word Knowledge subtests. The Arithmetic Reasoning, Data Interpretation, and Math Knowledge subtests were scored and combined to form the Quantitative composite. The Academic Aptitude composite was the combined score of the Verbal and Quantitative composites.

All 334 ASVAB items administered were entered into the analysis. The AFQT composite score was entered as the sum of applicable subtest standard scores; elsewhere, the subtest scores used were number right scores. Number right scores were used instead of converting ASVAB subtest scores to standard scores because the forms are parallel and equate about equally to the reference standard (Andberg, Stillwell, Prestwood, & Welsh, 1988). Linear transformations to standard scores would not affect the magnitude of relationships.

Analysis

A series of analyses were conducted to describe the tests and to evaluate the relationship between the AFOQT and the ASVAB. Means, standard deviations, skewness and kurtosis were computed separately for each ASVAB subtest, the AFQT composite, and each AFOQT subtest and specified composite (Verbal, Quantitative, and Academic Aptitude).

An intercorrelation matrix of the ASVAB and AFOQT subtests was computed. Correlations were corrected for restriction in range on the ASVAB due to use of the test as a selection device for entry into the enlisted force (Lawley, 1943). Unrestricted ASVAB parameter estimates for the corrections were obtained from the ASVAB 1980 American youth reference population for military applicants (McWilliams, 1980).

Using the corrected correlation matrix, the following analyses were performed. A series of stepwise regressions were conducted to estimate the amount of variance accounted for in the AFOQT composites by the 10 ASVAB subtests and AFQT composite. One of the AFOQT

composites (Verbal, Quantitative, or Academic Aptitude) was used as the criterion, and all ASVAB subtests and the AFQT were used as predictors in each regression.

A principal components factor analysis was conducted to find the common structure of the two tests. Using the corrected matrix, a five-factor solution, as found by Skinner and Ree (1987), was rotated obliquely. A Kaiser-Harris Type 2 oblique method (Harris & Kaiser, 1964) analytic rotation was used, and the resulting factors were interpreted.

A canonical correlation analysis was performed to relate the ASVAB (including the AFQT) and six AFOQT subtests. Wherry (1984) noted that a canonical correlation is accomplished by finding weighted vectors in each set of variables which most highly intercorrelate. Then, finding a pair orthogonal to the first, another pair of vectors is weighted and correlated. This process is continued until there are as many pairs of vectors as there are variables in the smaller set. As a result, sets of best-weighted equations are produced with weights for every variable. For example, if variable set A (A_1, A_2, A_3) and variable set B (B_1, B_2, B_3, B_4) are subjected to a canonical correlation analysis, the form of the first canonical equation will be:

$$W_1A_1 + W_2A_2 + W_3A_3 = W_4B_1 + W_5B_2 + W_6B_3 + W_7B_4$$

where the weights W_1 through W_7 are estimates of population parameters. It is usual to use the method of least squares for estimating these weights and also to report the correlation coefficient between the canonical variates. The second and third equations in this example would have the same form, yielding weights for eacn variable and a canonical correlation coefficient for each equation.

Usually, canonical correlation coefficients will decrease from canonical equation 1 to canonical equation 2 then 3 and so on. The test to determine the number of significant canonical equations is attributable to Bartlett (1947, 1954) and is distributed approximately as chi-squared. In all analyses allowing statistical tests, the Type I error rate was $p < .01$.

III. RESULTS AND DISCUSSION

Descriptive Statistics

Tables 4 and 6 present ASVAB and AFOQT descriptive analysis results for the current study. ASVAB subtests are identified with an "- A" suffix for "airman" and AFOQT subtests are identified with an "- O" suffix for "officer." Numbers of items scored, means, standard deviations, skewness, kurtosis, minimum scores, and maximum scores are shown. Data in Tables 5 and 7 were obtained from prior studies reporting the performance of applicants for enlistment tested on the ASVAB (Andberg et al., 1988) and of applicants for commissioning tested on the AFOQT (Skinner & Ree, 1987), respectively. Distributional statistics for the AFQT are not shown in Table 5 because these data derive from a published study (Andberg et al., 1988) which included an AFQT using a different algorithm (AR + WK + PC + NO/2).

Table 4 shows that ASVAB subtest mean scores were, on average, 3 to 4 raw score points higher than those for the sample of applicants in the Initial Operational Test and Evaluation (IOT&E) of ASVAB Forms 11, 12, and 13 as shown in Table 5 (Andberg et al., 1988). This was due to the effects of using ASVAB scores as a selector. Table 4 indicates that most of the subtests showed a moderate to extreme degree of negative skewness, with the Paragraph Comprehension-A (PC-A) subtest showing the greatest skewness (- .91). Auto and Shop Information-A (AS-A) was the most kurtotic of the subtests, with a flatter-than-normal shape.

Table 4. **Descriptive Statistics of ASVAB Scores for Basic Airmen**

ASVAB	# of Items	Mean	SD	Kurtosis	Skew	Min	Max
Subtest							
GS-A	25	19.12	3.30	-.70	-.19	10	25
AR-A	30	22.73	4.42	-.59	-.30	11	30
WK-A	35	29.13	4.22	.05	-.63	13	35
PC-A	15	12.67	1.97	.46	-.91	6	15
NO-A	50	41.60	6.94	-.57	-.59	19	50
CS-A	84	55.91	12.21	-.12	.11	8	84
AS-A	25	16.29	4.48	-.72	-.12	5	25
MK-A	25	17.17	4.69	-.69	-.28	5	25
MC-A	25	17.39	3.71	-.17	-.31	7	25
EI-A	20	13.39	3.20	-.60	.06	6	20
Composite							
AFQT[a]	105	218.77	19.22	-.65	-.06	155	257

[a]Armed Forces Qualification Test score: AFQT = 2(WK + PC) + AR + MK (Standard Scores).

Table 5. **Descriptive Statistics ASVAB Forms 11, 12, and 13 Subtest Scores IOT&E Sample**

ASVAB	# of Items	Mean	SD	Kurtosis	Skew	Min	Max
Subtest							
GS-A	25	16.43	4.98	-.68	-.22	.67	25
AR-A	30	19.00	6.59	-.95	-.12	1.33	30
WK-A	35	25.38	6.91	-.47	-.55	1.50	35
PC-A	15	11.07	3.08	-.20	-.68	.00	15
NO-A	50	36.59	8.79	-.28	-.39	.66	50
CS-A	84	50.08	13.05	.33	-.12	.33	84
AS-A	25	15.51	5.52	-.97	-.16	.83	25
MK-A	25	12.83	5.98	-.92	.35	.17	25
MC-A	25	15.30	4.83	-.72	-.17	1.00	25
EI-A	20	12.11	4.02	-.74	-.05	.17	20

Note. From "Initial operational test and evaluation of ASVAB Forms 11, 12, and 13: Parallelism of the new forms" (AFHRL-TR-87-65(II)) by Andberg, M.A., Stillwell, W.G., Prestwood, J.S., & Welsh, J.R. (1988).

[a]AFQT composite score not available.

Table 6 presents the results of the descriptive analyses of the AFOQT subtest raw scores and composite percentile scores. The performance of the basic airmen on the subtests was lower, on average, than that of applicants for officer commissioning (see Table 7). Mean scores on the AFOQT subtests were 2 to 3 raw score points above chance. Further, most of the subtests showed a moderate degree of positive skewness, with e Math Knowledge subtest showing the greatest amount (.65). The following factors may have contributed to the lower AFOQT raw scores observed for basic airmen. First, the General Answer Sheet Type C was used instead of the operational AFOQT answer sheet. This could lead to differences in scores due to answer sheet effects (Wegner & Ree, 1985). However, the two answer sheets were inspected and found to be consistent in style and format. Second, the AFOQT is designed for

examinees with college experience. Enlisted airmen are traditionally recent high school graduates. Another factor could be motivation. The BMT subjects were told at the time of AFOQT testing that their test scores would not be used operationally. This may have lowered their performance.

Table 6. **Descriptive Statistics of AFOQT Form O Scores for Basic Airmen**

AFOQT	# of Items	Mean	SD	Kurtosis	Skew	Min	Max
Subtest							
VA-O	22	8.96	2.65	-.45	.06	2	16
AR-O	21	7.46	3.47	.10	.54	0	18
RC-O	25	8.30	3.25	-.33	.32	1	17
DI-O	23	7.34	2.41	-.38	.18	1	14
WK-O	24	7.24	2.95	-.34	.38	1	16
MK-O	25	6.60	2.93	.20	.65	1	15
Composite							
Verbal	71	24.50	7.17	-.18	.40	4	45
Quantitative	69	21.41	6.74	.84	.80	5	47
Academic Aptitude[a]	140	45.90	12.30	.41	.69	16	92

[a]Academic Aptitude = Verbal + Quantitative (raw score).

Table 7. **Descriptive Statistics of AFOQT Form O Scores for Officer Applicant Sample[a] (N = 3,000)**

Subtest	# of Items	Mean	SD	Kurtosis	Skew
VA-O	22	13.36	4.23	-.40	-.39
AR-O	21	11.00	4.40	-.66	.07
RC-O	25	15.83	5.93	-.93	-.30
DI-O	23	11.15	3.93	-.36	.18
WK-O	24	13.28	5.83	-.99	.08
MK-O	25	14.48	6.04	-1.07	-.04

Note: From "Air Force Officer Qualifying Test (AFOQT): Item and factor analysis of Form O" (AFHRL-TR-86-68) by Skinner, J., & Ree, M.J. (1987).

[a]Minimum and maximum not available.

Subtest and Composite Intercorrelations

Table 8 shows the matrix of intercorrelations--uncorrected for restriction of range due to selection--of AFOQT and ASVAB subtests. The matrix shows a set of mostly positively intercorrelated subtests, with a few ASVAB subtests showing negative intercorrelations. The few negative correlations were probably due to range restriction (Levine, 1972). Once corrected for restriction in range (see Table 9), the matrix showed a set of positively intercorrelated subtests. All further analyses used the corrected matrix of intercorrelations, as they are better estimates of the true relationships in the population.

Table 8. **Intercorrelation Matrix of AFOQT and ASVAB Subtests (uncorrected)**

Subtest																
GS-A	1.00															
AR-A	.33	1.00														
WK-A	.58	.30	1.00													
PC-A	.33	.31	.45	1.00												
NO-A	.00	.29	.02	.06	1.00											
CS-A	-.11	.20	.06	.18	.54	1.00										
AS-A	.30	.16	.16	.04	-.19	-.22	1.00									
MK-A	.40	.61	.39	.34	.28	.20	.04	1.00								
MC-A	.38	.41	.31	.23	-.05	.02	.48	.36	1.00							
EI-A	.43	.27	.30	.23	-.12	-.07	.55	.23	.50	1.00						
VA-O	.45	.38	.49	.37	.14	.10	.18	.44	.34	.27	1.00					
AR-O	.35	.60	.28	.25	.23	.15	.22	.55	.39	.31	.40	1.00				
RC-O	.44	.37	.49	.42	.17	.12	.08	.41	.32	.27	.50	.42	1.00			
DI-O	.28	.30	.23	.26	.10	.11	.16	.31	.25	.23	.31	.37	.36	1.00		
WK-O	.42	.29	.54	.34	.13	.08	.08	.3[illegible]	.25	.25	.44	.35	.51	.25	1.00	
MK-O	.30	.32	.23	.22	.21	.09	.08	.48	.27	.14	.33	.44	.36	.28	.28	1.00
	GS-A	AR-A	WK-A	PC-A	NO-A	CS-A	AS-A	MK-A	MC-A	EI-A	VA-O	AR-O	RC-O	DI-O	WK-O	MK-O

Note. Column absolute maximum underlined.

Table 9. **Intercorrelation Matrix of AFOQT and ASVAB Subtests (corrected)**

Subtest	GS-A	AR-A	WK-A	PC-A	NO-A	CS-A	AS-A	MK-A	MC-A	EI-A	VA-O	AR-O	RC-O	DI-O	WK-O	MK-O
GS-A	1.00															
AR-A	.72	1.00														
WK-A	.80	.71	1.00													
PC-A	.69	.67	.80	1.00												
NO-A	.52	.63	.62	.61	1.00											
CS-A	.45	.52	.55	.56	.70	1.00										
AS-A	.64	.53	.53	.42	.31	.23	1.00									
MK-A	.70	.83	.67	.64	.62	.52	.42	1.00								
MC-A	.70	.68	.59	.52	.41	.34	.74	.60	1.00							
EI-A	.76	.66	.68	.57	.42	.34	.75	.59	.74	1.00						
VA-O	.77	.74	.81	.74	.61	.52	.54	.72	.63	.66	1.00					
AR-O	.71	.83	.67	.62	.60	.49	.55	.78	.66	.66	.72	1.00				
RC-O	.76	.73	.81	.77	.63	.53	.49	.70	.61	.65	.80	.73	1.00			
DI-O	.62	.62	.59	.59	.48	.45	.47	.60	.54	.55	.63	.65	.65	1.00		
WK-O	.74	.68	.83	.73	.61	.51	.47	.67	.57	.63	.77	.68	.80	.58	1.00	
MK-O	.60	.62	.56	.55	.54	.41	.40	.69	.53	.49	.62	.67	.63	.54	.58	1.00

Note: Column absolute maximum underlined.

For ASVAB versus AFOQT subtests, the highest corrected correlations obtained (.83) were between the Arithmetic Reasoning-A and the Arithmetic Reasoning-O and Math Knowledge-O subtests (all of which assess quantitative aptitude) and between the Word Knowledge-A and Word Knowledge-O subtests (both of which assess verbal aptitude). The lowest correlation (.40) was between Math Knowledge-O (MK-O) and Auto and Shop Information-A (AS-A), a specialized subtest. In general, the verbal aptitude subtests showed higher correlations with other verbal aptitude subtests than with other subtests. The same trend was observed for the quantitative aptitude subtests. The technical subtests (AS-A, MC-A, EI-A,) correlated lower with the remaining AFOQT and ASVAB subtests. These findings suggested that at least three factors could be expected from a factor analysis: verbal, quantitative, and trade/technical--with possibly a fourth which taps speededness, as revealed by the fairly low intercorrelations of NO-A and CS-A to the AFOQT and ASVAB subtests.

Regression Analyses

Stepwise regressions were conducted to estimate the amount of variance accounted for in each AFOQT composite by the ASVAB subtests and AFQT composite. For each regression, one AFOQT composite (Verbal, Quantitative, or Academic Aptitude) was selected as the criterion variable and all ASVAB subtests and the AFQT composite were used as predictor variables. Tables 10 through 12 show the results of the stepwise regressions. Results indicate that all but one of the ASVAB variables, Word Knowledge-A (WK-A), entered significantly ($p < .01$) into the prediction of the AFOQT composites. The WK-A subtest failed to contribute significantly to the prediction of the AFOQT Quantitative composite (see Table 11).

Tables 10 through 12 show that the AFQT is the most potent predictor of all three AFOQT composites, with relatively small standard errors of estimates of 5.15, 5.33, and 8.23 percentile points for the AFOQT Verbal, Quantitative and Academic Aptitude composites, respectively. This is not surprising because the AFQT consists of verbal and quantitative subtests. The multiple correlations were .75, .69 and .78 for the three AFOQT composites predicted by ASVAB subtests and the AFQT composite.

AR-A and MK-A, two subtests that measure quantitative attributes, entered at steps 3 and 4 in the AFOQT Verbal composite prediction equation while WK-A and PC-A, two subtests that measure verbal attributes, entered at steps 9 and 10 in the AFOQT Verbal composite prediction equation (see Table 10). This is explained by their negative regression weights adjusting for the quantitative and verbal attributes found in the AFQT which entered at step 1. A similar result was observed in the AFOQT Quantitative composite prediction equation. Word Knowledge-A (WK-A), entered at step 2, with a negative weight adjusting for the verbal attributes in the AFQT, while MK-A and AR-A, two quantitative subtests, entered at step 8 and step 11, respectively. Coding Speed-A (CS-A), a speeded subtest, is the last or next to last variable entered in all three regression models. This subtest (CS-A) added less than .0003 to the R^2 for all three prediction equations.

Factor Analysis

A principal components factor analysis was conducted. After inspection of solutions involving from 1 to 5 factors, the 5-factor solution was judged to best represent the data. Table 13 shows the loadings for the unrotated 5-factor principal components solution. The first principal component (Factor I) was judged to be an estimate of general ability or the psychometric "g" of the set of subtests, a finding consistent with numerous other investigations (Hotelling, 1933a, 1933b). It should be noted that all the loadings on the first factor were positive, as would be

Table 10. **Stepwise Regression Analysis – AFOQT Verbal**

Step	Variable entered	R	R^2	R^2 Change	Standard err est	Regression weight
1	AFQT	.697277	.486196	.486196	5.152505	.723688
2	GS-A	.716819	.513830	.027634	5.016914	.168857
3	AR-A	.724802	.525338	.011508	4.962018	-.669312
4	MK-A	.730451	.533558	.008220	4.923675	-.638748
5	NO-A	.736371	.542243	.008685	4.882402	.150594
6	MC-A	.740668	.548589	.006346	4.853199	.090242
7	EI-A	.741167	.549329	.000739	4.853993	.039701
8	AS-A	.741546	.549890	.000561	4.855751	-.025546
9	WK-A	.741845	.550334	.000444	4.858151	-.678040
10	PC-A	.745026	.555064	.004730	4.837313	-.299368
11	CS-A	.745226	.555362	.000298	4.840486	-.021770

Table 11. **Stepwise Regression Analysis – AFOQT Quantitative**

Step	Variable entered	R	R^2	R^2 Change	Standard err est	Regression weight
1	AFQT	.614896	.378097	.378097	5.327495	.235894
2	WK-A[a]	.652663	.425969	.047871	5.123332	-.416446
3	AS-A	.667296	.445284	.019316	5.041313	.084384
4	NO-A	.674770	.455314	.010030	5.000413	.114587
5	GS-A	.682289	.465518	.010203	4.958210	.137368
6	MC-A	.686115	.470754	.005236	4.938709	.078692
7	PC-A	.688933	.474629	.003875	4.925437	-.081887
8	MK-A	.689773	.475787	.001158	4.924855	.077755
9	EI-A	.689988	.476083	.000297	4.928324	.020090
10	CS-A	.690130	.476279	.000196	4.932279	.016527
11	AR-A	.690131	.476281	.000002	4.937161	-.007743

[a]Nonsignificant $p > .01$.

Table 12. **Stepwise Regression Analysis – AFOQT Academic Aptitude**

Step	Variable entered	R	R^2	R^2 Change	Standard err est	Regression weight
1	AFQT	.744086	.553664	.553664	8.229888	.959567
2	GS-A	.755879	.571353	.017689	8.073018	.306226
3	NO-A	.762864	.581961	.010608	7.980276	.265181
4	MC-A	.771151	.594674	.012713	7.865683	.168934
5	EI-A	.772310	.596463	.001790	7.855990	.059710
6	WK-A	.773229	.597884	.001420	7.849854	-1.094461
7	AR-A	.774293	.599530	.001647	7.841470	-.677040
8	AS-A	.774723	.600196	.000666	7.842674	.058837
9	MK-A	.774840	.600377	.000181	7.848646	-.560977
10	PC-A	.776505	.602960	.002583	7.830979	-.381244
11	CS-A	.776509	.602966	.000006	7.838685	-.005243

expected. Further, the range of loadings was relatively small: from .62 for ASVAB Coding Speed (CS-A), a relatively less reliable test (Palmer, Hartke, Ree, Welsh, & Valentine, 1988), to .88 for AFOQT Reading Comprehension (RC-O), a relatively more reliable test (Rogers, Roach, & Wegner, 1986). This small range implies that the subtests are similar in the extent to which each taps or measures general ability.

Table 13. **Unrotated Principal Components Factor Loadings**

	Factors[a]				
Subtests	**I**	**II**	**III**	**IV**	**V**
General Science-A	.875	.173	-.123	-.071	-.036
Arithmetic Reasoning-A	.874	-.006	.230	.022	-.083
Word Knowledge-A	.880	-.065	-.319	-.105	-.075
Paragraph Comprehension-A	.821	-.192	-.276	-.122	.021
Numerical Operations-A	.720	-.453	.040	.307	-.085
Coding Speed-A	.623	-.521	-.070	.477	.075
Auto and Shop Information-A	.655	.600	-.064	.287	.022
Math Knowledge-A	.839	-.124	.321	-.093	-.120
Mechanical Comprehension-A	.767	.435	.102	.187	-.051
Electrical Information-A	.792	.420	-.110	.116	-.038
Verbal Analogies-O	.883	-.036	-.114	-.117	-.028
Arithmetic Reasoning-O	.863	.025	.290	-.009	-.017
Reading Comprehension-O	.885	-.093	-.132	-.169	.019
Data Interpretation-O	.742	.001	.107	-.082	.648
Word Knowledge-O	.849	-.095	-.235	-.181	-.080
Math Knowledge-O	.734	-.088	.406	-.210	-.093

[a]Column maximum is underlined.

The remaining four factors, though not so easily interpreted, convey some meaning. Factor II appears to be gender-related, which is consistent with the findings of Jones (1988). Subtests with large negative loadings are the NO-A and CS-A subtests, on which women usually score better than men. The AS-A, MC-A, and EI-A subtests, which had large positive loadings, are those on which men usually score better than women. Factor III appears to be a quantitative factor, with high loadings on MK-A and MK-O. High loadings on NO-A and CS-A, two speeded subtests, identify Factor IV as Speeded. Factor V has one unique subtest, DI-O, that loads above +.30 (the conventional level of a significant loading) and has thus been identified simply as Data Interpretation. The first principal component also loads DI-O, but Factor V shows the uniqueness of this subtest.

It is important to note that when factors are rotated, the first factor loses its status as the highest common factor; its variance is scattered among the rotated primary factors, and what could properly be called a "g" factor disappears (Jensen, 1987).

Table 14 shows the obliquely rotated factor pattern loadings. The pattern matrix was chosen over the structure matrix because of its ability to delineate more clearly the grouping or clustering of variables. Table 15 shows the rankings of subtest factor loadings of .30 or greater after the oblique rotation. Factor I is composed of ASVAB trade/technical and "g"-related subtests on both the ASVAB and AFOQT and has been termed the Technical Factor. Factors II and III are clearly Verbal and Quantitative, respectively. Factor IV includes the speeded ASVAB subtests, and is identified as the Speed Factor. Factor V has one subtest (DI-O) that loads above +.30 and has been identified simply as the Data Interpretation Factor.

Table 14. **Obliquely Rotated Factor Loadings**

Subtests	Factors[a] I	II	III	IV	V
General Science-A	.561	.328	.142	.034	.140
Arithmetic Reasoning-A	.325	.121	.498	.212	.106
Word Knowledge-A	.422	.600	-.010	.150	.077
Paragraph Comprehension-A	.232	.598	-.007	.192	.175
Numerical Operations-A	.035	.189	.212	.708	-.003
Coding Speed-A	-.015	.092	-.034	.884	.116
Auto and Shop Information-A	.939	-.252	-.023	.064	.123
Math Knowledge-A	.141	.199	.638	.164	.082
Mechanical Comprehension-A	.768	-.157	.245	.087	.094
Electrical Information-A	.810	.044	.058	.044	.101
Verbal Analogies-O	.357	.450	.179	.115	.153
Arithmetic Reasoning-O	.294	.069	.536	.160	.189
Reading Comprehension-O	.279	.514	.163	.100	.211
Data Interpretation-O	.058	.035	.082	.074	.898
Word Knowledge-O	.324	.608	.093	.088	.084
Math Knowledge-O	.045	.176	.716	.009	.118

[a]Column maximum is underlined.

Table 15. **Ranks of Loadings[a] for the Rotated Factor Matrix**

Subtests	Factors I	II	III	IV	V
General Science-A	4	6			
Arithmetic Reasoning-A	7		4		
Word Knowledge-A	5	2			
Paragraph Comprehension-A		3			
Numerical Operations-A				2	
Coding Speed-A				1	
Auto and Shop Information-A	1				
Math Knowledge-A			2		
Mechanical Comprehension-A	3				
Electrical Information-A	2				
Verbal Analogies-O	6	5			
Arithmetic Reasoning-O			3		
Reading Comprehension-O		4			
Data Interpretation-O					1
Word Knowledge-O	8	1			
Math Knowledge-O			1		

[a]No subtest with loading less than .30 ranked.

The intercorrelations of the obliquely rotated factors are given in Table 16. The median intercorrelation of the factors was .35, with a range of .25 to .39.

Table 16. **Intercorrelation of Factors**

	Factors				
	I	II	III	IV	V
I	1.00				
II	.35	1.00			
III	.38	.35	1.00		
IV	.25	.38	.32	1.00	
V	.39	.35	.36	.28	1.00

Canonical Correlation Analyses

The results of the canonical correlational analyses are shown in Table 17. With a Type I error rate of $p < .01$, three statistically significant canonical variates were found. Standardized score coefficients for these variates are also presented in Table 17.

Table 17. **Canonical Correlation**

	Eigenvalue	Canonical correlation	Wilk's lambda	Chi-square	df	p
1	.88118	.93871	.06834	1359.09723	60	.000
2	.33362	.57759	.57511	280.18968	45	.000
3	.08151	.28550	.86304	74.60745	32	.000
4	.03751	.19367	.93962	31.54405	21	.065
5	.01981	.14073	.97624	12.18155	12	.431
6	.00404	.06354	.99596	2.04929	5	.842

Coefficients[a] for Canonical Variables of the First Set (ASVAB)

	Canvar 1	Canvar 2	Canvar 3
GS-A	.15469	.10727	-.39222
AR-A	.15875	-.83049	1.49233
WK-A	.27715	1.12732	.42532
PC-A	.13913	.33652	-.25792
NO-A	.11472	.02005	-.52255
CS-A	-.00071	-.08093	.33111
AS-A	.01662	-.32916	.11449
MK-A	.19718	-.50628	-1.34750
MC-A	.07891	-.00039	-.35725
EI-A	.04196	.00091	.50119

Coefficients[a] for Canonical Variables of the Second Set (AFOQT)

	Canvar 1	Canvar 2	Canvar 3
VA-O	.28636	.23799	.05701
AR-O	.26425	-1.30974	.83679
RC-O	.22646	.55074	.10551
DI-O	.06051	-.10034	.09819
WK-O	.22883	.77236	.07451
MK-O	.07104	-.24498	-1.39371

[a]Canonical variable weights for numbered variable.

The first canonical correlation of .939 shows a very high level of overlap between the two test batteries. Interpretation of coefficients of the canonical weights for the first canonical variate indicates that measures of g, quantitative and verbal skills predominate. The second canonical variate is less interpretable ($\underline{R}$ = .578). However, the weights for both Word Knowledge subtests (in ASVAB and AFOQT) and those for the reading subtests (PC in the ASVAB and RC in AFOQT) are positive, while those for the mathematical subtests (AR, MK in both and DI in AFOQT) are negative. The third canonical variate strongly and positively weights both Arithmetic Reasoning subtests while strongly and negatively weighting both Math Knowledge subtests, suggesting that reasoning without effects of mathematical computation is being reflected ($\underline{R}$ = .286).

There is a discrepancy between the finding of three significant canonical variates and the finding of five factors in the principal components factor analysis. The difference in the results of these two analyses resides in the nature and goals of the two analytic procedures. In factor analysis a statistical test on the number of significant latent roots (related to the eigenvalues) is rarely performed. This can lead to the extraction of factors of which some may be due to error variance. A second difference is the rotation of the reference axes, which redistributes variance among the factors and facilitates interpretability. Because rotation is not accomplished during canonical analyses, the components are frequently difficult or impossible to interpret. Finally, no fit of the data to the solution is computed in the ordinary exploratory factor analysis. Canonical correlation analyses provide an index of fit in the square of the reported canonical correlation coefficients. In general, factor analysis sacrifices mathematical precision for interpretability whereas canonical correlation sacrifices interpretability for mathematical precision.

IV. CONCLUSIONS

Several major conclusions may be drawn from the analyses of the common elements of the AFOQT and ASVAB. The present findings have implications for future test forms concerning item development, validation, and operational use.

The regression analyses showed that the AFQT could be used as a good indicator of success on the AFOQT Verbal, Quantitative, and Academic Aptitude Composites. This could directly impact the selection of officers during wartime mobilization and peacetime selection of airmen into the Airman Education and Commissioning Program (AECP). If the USAF needed to increase the officer force rapidly, airmen with high AFQT scores could be selected first to take the AFOQT This would allow the Air Force to select potential officers in the most efficient manner and reduce expenses by testing only the most promising candidates with the AFOQT

The AECP allows airmen on active duty to earn baccalaureate degrees in needed academic fields. The AECP could use AFQT scores as indicators of how airmen would be expected to score on the AFOQT, one of the eligibility requirements for the program. By knowing airmen's AFQT scores, a supervisor could identify those airmen who might be candidates for admission to the AECP.

The intercorrelations and factor analysis performed indicate that both tests are measuring much the same attributes. The high item content overlap among the verbal subtests (WK-A, PC-A, GS-A, VA-O, RC-O, and WK-O) and among the quantitative subtests (AR-A, MK-A, AR-O, and MK-O) suggests that the AFOQT and ASVAB could share the same item pool for specific subtests.

A related issue concerns the use of basic airmen for field-testing experimental AFOQT items. It is frequently not logistically nor economically feasible to try out new AFOQT items with officer applicants, the preferred target population (Berger, Gupta, Berger, & Skinner, 1988). The results

of the present investigation indicated that the airmen in BMT scored, on average, just above chance on the AFOQT subtests. This level of performance could lead to developing or selecting easier-than-desired items for the AFOQT. Berger et al. (1988) explain in detail how to compensate for the low scores and still be able to use BMT airmen in the early stages of item pool development for the AFOQT.

Finally, a general factor or "g" ability was found to exist in both the AFOQT and ASVAB. All subtests strongly loaded on the first principal component of the unrotated matrix. This indicates strong convergent validity between the AFOQT and ASVAB. Correlations between scores on subtests measuring the same trait are high. These similar subtests also load on the same factors, indicating convergent validity for the two batteries.

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